ELECTRICITY

All the physical phenomena related to **Charge** comes under electricity.

Electricity is controllable and most convenient form of energy for a variety of uses everywhere. It can easily be stored and transported to long distances.

We can divide electricity in to two parts-
Electrostatics (for stationary charge**)**
Current electricity (for moving charge**)**

A. Under **Electrostatics** we have to study
- Electric Potential
- Electric Potential Difference
- Electrostatic field and force...etc.

B. Under **Current Electricity** we have to study
- Electric Current
- Electric Circuit
- Ohm's Law
- Resistance & Resistivity Constant
- Combination of Resistances
- Heating Effect of Electric Current
- Electric Power
- Domestic Circuit ...etc.

Charge

- A physical property of matter where it has more or fewer electrons than protons in its atoms.

SI unit - Coulomb 'C'

***Properties of charge:-**
- Charge has magnitude but no direction, similar to the mass.
- There are two types of charges:- positive (fewer electrons) &
  - negative (excess electrons)
- Opposite charges attract each other , similar charges attract each other.
- Additive property: charges add up algebraically like real numbers
- Conservation of charge: the total charge of the isolated system is always conserved.
- Quantisation of charge: all free charges are integral multiples of a basic unit of charge denoted by e.

$q = ne$ Where, $e = 1.602192 \times 10^{-19}$ C

***Charge development:-**
- by friction. Ex- rubbing of glass rod (+) with silk (-).
  -rubbing of rubber rod (-) with woolen cloth(-).
- by induction.(without touching)
- by conduction. (flow of charge from higher potential to lower potential)

Classification of matter in terms of electricity :-

- Conductors - materials which allow current to pass through it freely. Ex- silver(best), copper, aluminium, graphite etc.
- Insulators - materials which do not allow current to pass through it. Ex- dry wood, cloths, papers, plastics etc.
- Semiconductors - materials which are generally insulator but behaves like conductor in special conditions. Ex- silicon, germanium etc.

#Electrostatics :-

* **Electrostatic/Electric potential(Vp) -** the electrostatic potential (Vp) at any point p in a region with electrostatic field is the work done in bringing a unit positive charge (without acceleration) from infinity to that point.

$V_p = W_{\infty \to p}/q$, where W is work done from infinity to point 'p'. and q is test charge

* **Electrostatic/Electric potential difference (Vab) -** the electrostatic potential difference (Vab) between two points 'a' and 'b' in a region with electrostatic field is the work done in bringing a unit positive charge (without acceleration) from point 'a' to point 'b'.

$V_{ab} = W_{a \to b}/q$, where symbols have usual meaning

#Current Electricity:-

* **Electric current -**the amount of charge flowing through a particular area in unit time.

-SI unit - Ampere 'A'

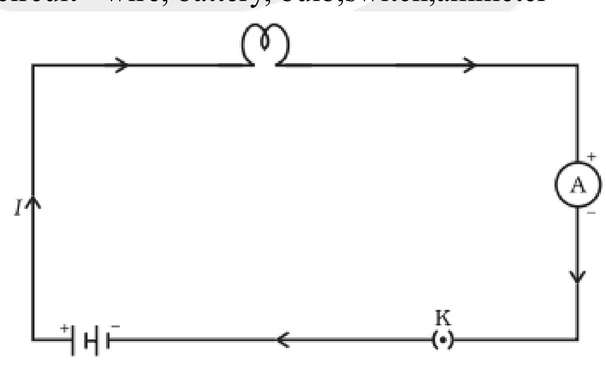
-Formula, $I = Q/t$

-Direction of electric current: Conventionally, in an electric circuit the direction of electric current is taken as opposite to the direction of the flow of electrons, which are negative charges.

Also in a circuit always from higher potential(+terminal of battery) to lower potential(-terminal of battery).

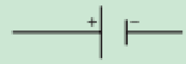
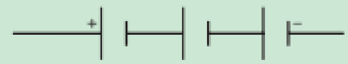
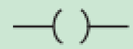
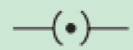
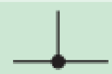
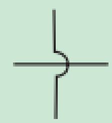
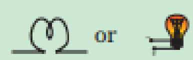
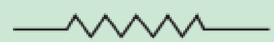
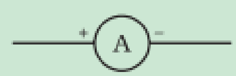
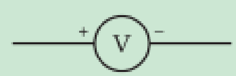
* **Electric circuit-** A continuous and closed path of an electric current is called an electric circuit.

- Essential components of electric circuit - wire, battery, bulb,switch,ammeter



-A schematic circuit diagram

Symbols of some commonly used components in circuit diagrams

Sl. No.	Components	Symbols
1	An electric cell	
2	A battery or a combination of cells	
3	Plug key or switch (open)	
4	Plug key or switch (closed)	
5	A wire joint	
6	Wires crossing without joining	
7	Electric bulb	
8	A resistor of resistance *R*	
9	Variable resistance or rheostat	
10	Ammeter	
11	Voltmeter	

Ohm's Law:

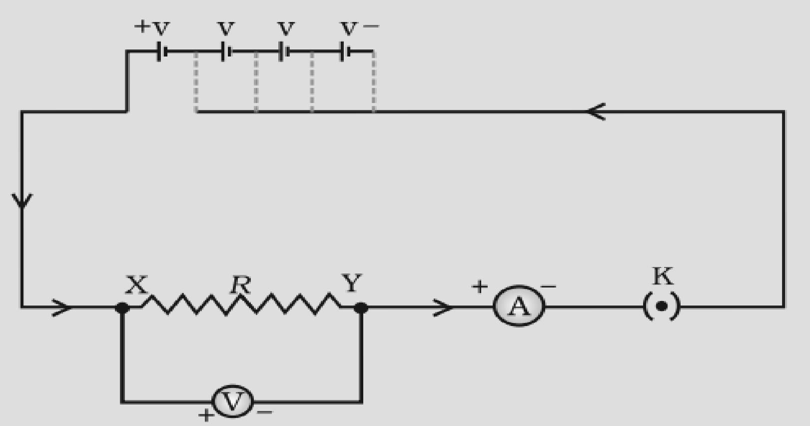
"the electric current 'I' flowing through a metallic wire is directly proportional to the potential difference 'V', across its ends provided its temperature remains the same. This is called Ohm's law."

Mathematically, $V \propto I$,
=> $V = RI$, where V is potential difference
I is electric current and
R is a proportionality constant called **resistance.**

- for the given metallic wire at a given temperature R is constant.
- the SI unit of resistance is ohm 'Ω'.
- 1 ohm = 1 volt / 1 ampere

- "If the potential difference across the two ends of a conductor is 1 V and the current through it is 1 A, then the resistance R, of the conductor is 1 Ω."
- a device called **rheostat** is often used to change the resistance in the circuit without changing the voltage.
- a conductor having some appreciable resistance is called a **resistor.**

Verification of Ohms Law :-

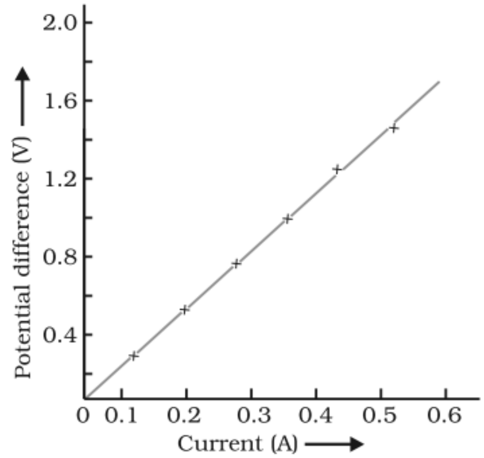


Electric circuit for studying Ohm's law

In this activity, with in circuit we have placed voltmeter across nichrome wire XY to measure voltage and ammeter connected in series to measure current flowing through circuit.
We will keep changing the no. of cells and observe the changes in V and I.
The we will find the ration V/I ...which should remain constant to verify Ohm's Law.

S. No.	Number of cells used in the circuit	Current through the nichrome wire, *I* (ampere)	Potential difference across the nichrome wire, *V* (volt)	*V/I* (volt/ampere)
1	1			
2	2			
3	3			
4	4			

- Plot a graph between *V* and *I*, and observe the nature of the graph.



V–I graph for a nichrome wire. A straight line plot shows that as the current through a wire increases, the potential difference across the wire increases linearly – this is Ohm's law.

V/I = 4 which is constant

In an ideal situation the graph will remain straight line.

*** FACTORS ON WHICH THE RESISTANCE OF A CONDUCTOR DEPENDS**

The resistance of the conductor depends
(i) on its length,
(ii) on its area of cross-section, and
(iii) on the nature of its material.
$R \propto l$
and $R \propto 1/A$
Combining Eqs.

we get $R \propto l/A$ or, $R = \rho\, l/A$

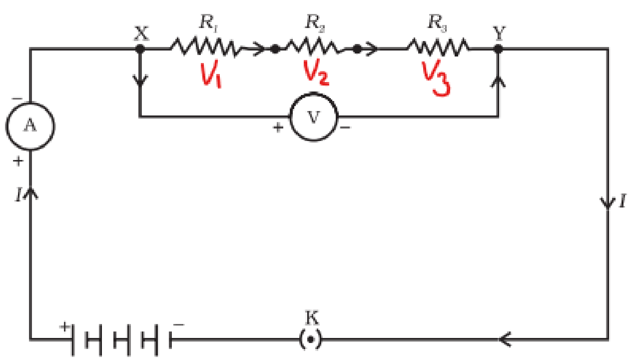
where ρ (rho) is a constant of proportionality and is called the electrical resistivity of the material of the conductor.
- The SI unit of resistivity is Ω m. It is a characteristic property of the material.
- Both the resistance and resistivity of a material vary with temperature.

- The resistivity of an alloy is generally higher than that of its constituent metals. Alloys do not oxidise (burn) readily at high temperatures.
For this reason, they are commonly used in electrical heating devices, like electric iron, toasters etc. Tungsten is used almost exclusively for filaments of electric bulbs.

* RESISTANCE OF A SYSTEM OF RESISTORS

There are two methods of joining the resistors together.

1. **Series Combination** (end to end)



Resistors in series

- The total potential difference across a combination of resistors in series is equal to the sum of potential difference across the individual resistors.

That is, $V = V_1 + V_2 + V_3$ ------------------(1)

- The current flowing through circuit is same 'I'.

Applying Ohm's law,

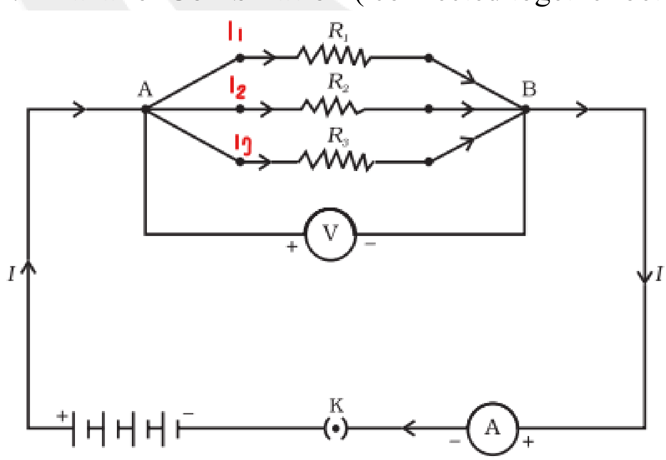
$V = IR_s$, and $V_1 = IR_1$, $V_2 = IR_2$, $V_3 = IR_3$

So,putting the values in equation (1) we get,

$IR_s = IR_1 + IR_2 + IR_3 = I (R_1 + R_2 + R_3)$

So, $\boxed{R_s = R_1 + R_2 + R_3}$

2. **Parallel Combination** (connected together between points X and Y).



Resistors in parallel

- The total current I, is equal to the sum of the separate currents through each branch of the combination. $I = I_1 + I_2 + I_3$ --------------------------(2)
- The voltage across all the resistors are same 'V'

On applying Ohm's law to each resistor, we have
$I = V/R_p$ and $I_1 = V/R_1$; $I_2 = V/R_2$; and $I_3 = V/R_3$
Putting these values in equation (2)
$V/R_p = V/R_1 + V/R_2 + V/R_3 = V(1/R_1 + 1/R_2 + 1/R_3)$

So,

$$1/R_p = 1/R_1 + 1/R_2 + 1/R_3$$

Use of parallel combination over series.
- A major disadvantage of a series circuit is that when one component fails the circuit is broken and none of the components works.
- The total resistance in a parallel circuit is decreased.
-Parallel combination is helpful particularly when each gadget has different resistance and requires different current to operate properly.

*** HEATING EFFECT OF ELECTRIC CURRENT**

If the electric circuit is purely resistive, that is, a configuration of resistors only connected to a battery; the source energy continually gets dissipated entirely in the form of heat. This is known as the heating effect of electric current.
Joule's law of heating.
Heat(H) produced in a resistor is
(i) directly proportional to the square of current (I) for a given resistance,
(ii) directly proportional to resistance(R) for a given current, and
(iii) directly proportional to the time(t)for which the current flows through the resistor.
So,

$$H = I^2 Rt$$

− The electric laundry iron, electric toaster, electric oven, electric kettle, electric heater and electric bulb are some of the familiar devices based on Joule's heating.

- Another common application of Joule's heating is the fuse used in electric circuits. It protects circuits and appliances by stopping the flow of any unduly high electric current.The fuses used for domestic purposes are rated as 1 A, 2 A, 3 A, 5 A, 10 A, etc.

*** ELECTRIC POWER**

- the rate at which electric energy is dissipated or consumed in an electric circuit.
− The power P is given by
  $P = VI$ Or $P = I^2R = V^2/R$ (applying Ohm's law)

- The SI unit of electric power is watt (W).
- It is the power consumed by a device that carries 1 A of current when operated at a potential difference of 1 V.
Thus, 1 W = 1 volt × 1 ampere = 1 VA

The commercial unit of electric energy is kilowatt hour (kW h), commonly known as 'unit'.
1 unit = 1 kW h = 1000 watt × 3600 second = 3.6×10^6 watt second = 3.6×10^6 joule (J)